IMPLICATIONS OF GRAVITY SIGNATURES OF RADIALLY FRACTURED DOMES. D. M. Janes, *Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853, USA, janes@astrosun.tn. cornell.edu*, E. P. Turtle, *Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA*, S. W. Squyres, *Center for Radiophysics and Space Research, Cornell University, Ithaca, NY 14853, USA.*

It is generally agreed that most venusian coronae are due to low density diapirs rising through the mantle to impinge on and deform the overlying crust [1,2,3]. However, while modeling of the surface displacements and stresses supports the hypothesis of diapiric uplift, it allows a fairly broad range of lithospheric thicknesses and diapir sizes, densities and depths, and cannot uniquely determine a specific combination of these model parameters for any given feature [3,4]. An additional open question is the source of the low density material comprising the diapir. If it is derived entirely from heating and thermal expansion, these diapirs may contribute significantly to the venusian heat budget. If, on the other hand, the density contrast is due to a phase change or partial melting of mantle material due to pressure release, then less heat is being carried to the surface of coronae, but important information regarding the composition of the venusian mantle may be derived from knowing the magnitude of the density contrast associated with the change in state. These two problems are obviously related in that the range of actual diapir density contrasts associated with coronae and related landforms can yield critical information on the source of that contrast. For example, a wide range of diapir density contrasts associated with radially fractured domes, thought to be the initial deformation stage of coronae, would be consistent with varying degrees of heating and thermal expansion, while a tightly clustered range of densities, particularly if they are too large to be easily accounted for by heating but are consistent with known phase transitions, would favor a compositional source.

The obvious place to look for additional information regarding the size and density contrasts of coronal diapirs is the gravity field of Venus. Free air gravity anomaly harmonic coefficients are now available to order and degree 90 [5]. The half wavelength resolution at this order is approximately 210 km, and would allow the determination of the dominant gravity signature of most coronae and related features. However, the coverage or the raw, line-of-sight accelerations on which the gravity harmonics are based varies with location on the planet so that the degree strength of the harmonic solution also varies, from order/degree 40 where the coverage is poor to 90 where it is optimal [5]. Therefore, for each corona or corona-like feature we wish to study, we first construct a free-air gravity map using only those harmonics of order and degree up to the local degree strength. We then determine the gravity anomaly due to the observed topography of the feature, using the method of Turtle and Melosh [6], described below, and Gaussian filter this anomaly down to the resolution equivalent to that of the highest harmonic of the local degree strength. Finally, the topographic gravity is subtracted from the observed free-air gravity anomaly to produce the Bouguer gravity anomaly which is due to the subsurface structure which we seek to model.

Our gravitational model follows the derivation of Turtle and Melosh [6] for the gravitational acceleration due to a ring mass anomaly. The vertical component of the gravitational acceleration due to the ring is given by:

$$g(z) = -\frac{2GMz}{\pi[(R-a)^2+z^2][(R+a)^2+z^2]^{1/2}} \times$$
$$E[\frac{4aR}{((R+a)^2+z^2)}]^{1/2}$$

where, G is the gravitational constant, M is the mass of the ring, a is the radius of the ring, and R and z are the radius and height, respectively, of the point at which the gravity is calculated. $E[\quad]$ represents a complete elliptic integral of the second kind.

We treat the corona structure as axially symmetric and break it into two components, the upwarped crust and the diapir. We assume that the crust/mantle interface follows the same shape as the surface topography. We thereby account for crustal upwarping but not for crustal thinning. We divide the upwarped crustal structure into a series of rings and determine the gravity anomaly due to each ring by solving the above equation numerically following Press *et al.* [7]. We then sum the contributions of the individual rings over the entire crustal structure. We treat the diapir as a sphere at depth and solve for its surface gravity anomaly following the analytical solution of Turcotte and Schubert [8]. The contributions from the upwarped crust/mantle boundary and the diapir are then summed to produce the total gravity anomaly. We then Gaussian filter the result to the resolution appropriate to the location of the feature being studied. We run several thousand models for each feature, varying crustal thickness and diapir size, density and depth. For each model we calculate a least squares fit to the observed gravity anomaly and then map out the least squares values in this four dimensional parameter space.

Our results for radially fractured domes reveal that the partial derivative of the least squares values with respect to the individual model parameters is largest for diapir radius and density contrast and is relatively small for crustal thickness and diapir depth. That is, our gravity modeling can place good constraints on the the former (the principal sources of the gravity anomaly) but only poor constraints on the latter. In general, the best fit diapir sizes are relatively small, ranging between 25 and 75 km in radius with an average of 40 km while the best fit diapir density contrasts for the radially fractured domes are large and tightly clustered, with most falling between 100 and 120 kg/m^3 but occasionally reaching as high as 180 kg/m^3. Best fit diapir depths and crustal thicknesses are invariably small, less than a few km, but considerably thicker crusts and deeper diapirs do not produce significantly worse fits to the observed gravity profiles.

A diapir density contrast of 100 kg/m^3 would require a temperature difference of approximately 1300 K with the surrounding mantle if the density contrast were solely derived from thermal expansion. Since this is unlikely, our preliminary results, then, favor a compositional, phase change mechanism, such as pressure release melting, as the source of the low density diapirs producing corona. This result is consistent with the observed association of coronae with areas of active extension and rifting [1,9].

The ability to place relatively tight constraints on the size and density of the diapirs in turn allows us to use these values as fixed parameters in our flexural uplift modeling. The addition of these two fixed parameters makes those models fully constrained and allows us to determine lithospheric thickness and diapir depth from the observed topography of these features. Small diapirs with large density contrasts imply shallow diapirs, as previously assumed, but result in thicker lithospheres than had been inferred by Janes et al [3]. Lithospheres can now be a few 10's of km thick, rather than the few kms they derived.

References

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